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FURTHER EXAMINATION OF THE
EQUATIONS FOR THE TIMES OF MAXIMUM LIGHT FOR SX PHOENICIS

From data published elsewhere (Coates et al., 1979), we have constructed the equations for the times of maximum light:

$$t_{\text{MAX}}(\text{pre-1960}) = 2433923.9618 + 0.054964519 \cdot E_1 - 0.00337 \sin 2\pi(0.28503379 \cdot E_1 + 0.074) \quad (1)$$

$$\text{and } t_{\text{MAX}}(\text{post-1960}) = 2438636.6170 + 0.054964438 \cdot E_2 - 0.00325 \sin 2\pi(0.28503575 \cdot E_2 - 0.107) \quad (2)$$

which yield values for the times of maximum light of SX Phe, t_{MAX} (calculated), that differ from the observations with an rms deviation of 0.0006 days in the case of equation (1) and 0.0009 days in the case of equation (2). E_1 is the number of cycles of the pre-1960 fundamental period since the epoch HJD 2433923.9618; E_2 is the number of cycles of the post-1960 fundamental period since the epoch HJD 2438636.6170, and the number of cycles between these two epochs is 85740.

We have made preliminary examinations of the residuals $[t_{\text{MAX}}(\text{observed}) - t_{\text{MAX}}(\text{calculated})]$ for all 314 observations of maximum light (Appendix 1) for systematic deviations which might provide evidence for another mode of oscillation of SX Phe. We find that for all groups of observations but two the residuals appear to be normally distributed about zero. A standard Student's t-test yields probabilities that each group of residuals is a sample from a normal distribution of residuals of mean zero, (Table 1).

It is seen that the two groups of observations made by Stock and Tapia between 1966 September 18 and 1966 November 1 appear to be exceptional.

Table 1
ANALYSIS OF RESIDUALS

Observer	No. of Maxima	Sample Mean (Units of 10^{-4} day)	Sample RMS Dev.	Probability (from t-test)
Eggen	8	1.1	10.8	0.808
Walraven	71	-0.1	5.3	0.624
Wilson and Walker	6	4.8	7.4	0.185
Wood	5	-2.6	4.4	0.237
Stock and Tapia	7	4.0	7.3	0.192
Stock and Tapia	*41	-5.0	6.9	0.000043
Stock and Tapia	*29	9.2	5.9	4.4×10^{-9}
Stock and Tapia	21	-3.4	7.6	0.053
Stock and Tapia	23	-2.9	7.8	0.095
Stock et al.	5	12.6	7.5	0.020
Elst	46	-1.0	8.4	0.458
Haefner	5	-0.4	14.2	0.958
Dale	7	2.3	8.3	0.488
Halprin	33	0.2	9.1	0.903
Halprin	7	0.3	10.7	0.937

*Refer to Table 2

Table 2
COMPARISON OF RESIDUALS FOR STOCK AND TAPIA

No. of Maxima	Sample Mean (Units of 10^{-4} Day)		Sample RMS Dev. (Units of 10^{-4} Day)		Probability	
	Old	Adjusted	Old	Adjusted	Old	Adjusted
41	-5.0	1.7	6.9	6.5	4.3×10^{-5}	0.086
29	9.2	-0.9	5.9	6.5	4.4×10^{-9}	0.489

The residuals for these observations are plotted in Figure 1. These results may be explicable in terms of some previously un-noticed instability in the behaviour of SX Phe, perhaps the temporary excitation of a third mode of oscillation. However, we cannot exclude the possibility that these groups of data are based on an incorrect conversion between Geocentric and Heliocentric time. If we assume that all the observations have been converted to Heliocentric time using a constant factor appropriate to JD 2439410, which is the approximate mid-time for these groups, then the form of Figure 1 may be explained. Assuming that the conversion to HJD was made in this way, we have recovered adjusted residuals for these observations, and these are shown in Figure 2. Table 2 then gives the new probability values from a t-test, and it is clear that the adjusted residuals are much more likely to be a sample from a normal distribution of residuals of mean zero.

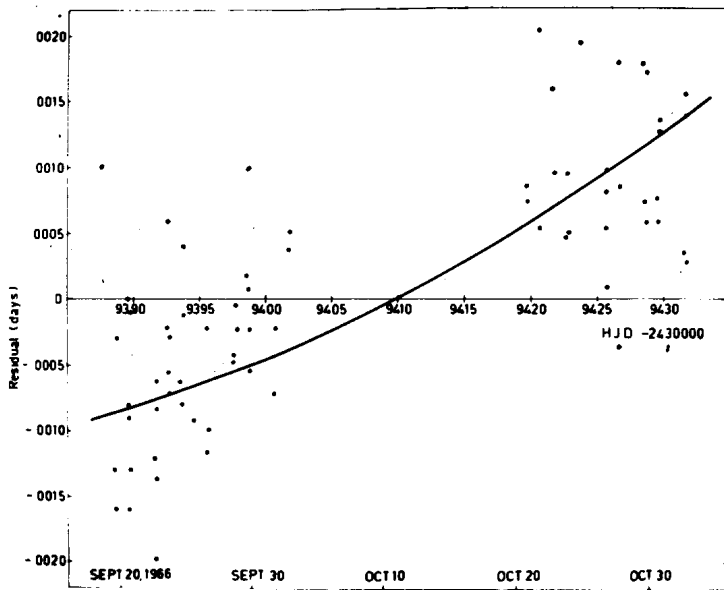


Figure 1: Plot of residuals for Stock and Tapia maxima Sept.-Nov. 1966. The curve represents the required correction to the data assuming that a constant geocentric to heliocentric time conversion factor calculated for mid-time was originally used.

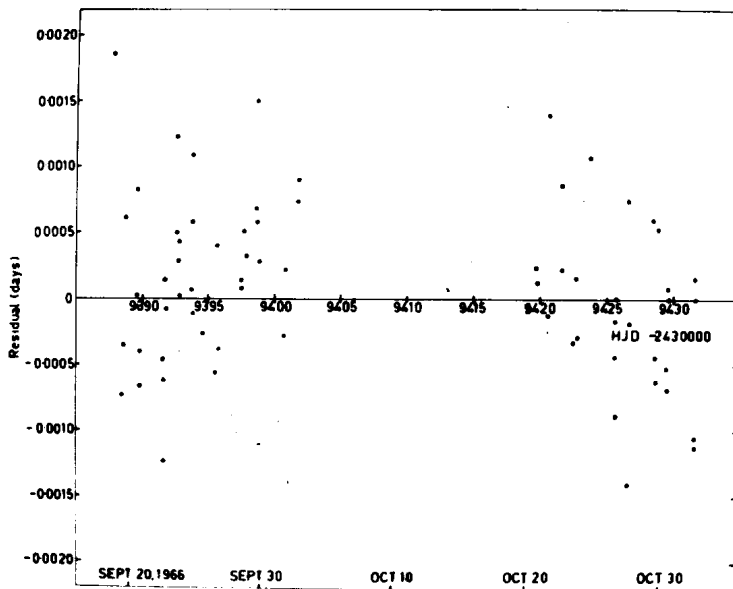


Figure 2: Plot of the adjusted residuals for Stock and Tapia using the corrections acquired from the curve in Fig.1.

Analysis of the residuals for periodicity has not as yet provided sufficient evidence to support the existence of an additional mode of oscillation of SX Phe.

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Reference:

Coates, D.W., Dale, M., Halprin, L., Robinson, J. and Thompson, K.,
1979, Mon.Not.R. astr. Soc. 187, 83

Appendix. We give for reference the residuals determined from our equations for all observed times of maximum light.

Pre-1960 Residuals

Observed Time (HJD-2430000)	Residual (Days)	Observed Time (HJD-2430000)	Residual (Days)
3923.95960	-0.00070	4238.52040	-0.00030
3924.01310	-0.00100	4238.58170	0.00090
3926.92770	-0.00140	4238.63560	-0.00010
3926.98920	0.00110	4240.39220	-0.00010
3927.03920	0.00010	4240.50440	0.00040
3927.09340	0.00170	4251.43670	-0.00060
3927.15240	0.00070	4254.29570	-0.00040
3927.20720	0.00040	4254.35180	0.00000
4224.51090	0.00070	4254.41140	-0.00010
4224.56390	-0.00030	4254.46280	-0.00090
4227.42540	0.00120	4254.51530	0.00020
4227.52810	0.00030	4254.57440	0.00010
4227.58830	0.00060	4278.26200	0.00090
4227.64320	0.00030	4278.32170	0.00060
4228.41280	0.00030	4278.37280	-0.00070
4228.51830	-0.00070	4278.42550	0.00090
4228.57820	-0.00020	4278.48300	-0.00070
4228.63010	0.00030	4283.26180	-0.00020
4229.34860	0.00070	4283.32200	-0.00010
4229.39940	-0.00010	4283.42670	0.00010
4229.51130	0.00030	4283.48310	-0.00120
4229.56700	0.00000	4293.32280	-0.00050
4231.37560	0.00060	4293.38100	-0.00050
4231.43450	0.00020	4293.43210	0.00030
4231.49110	0.00010	4293.48460	-0.00100
4231.54080	-0.00010	4294.31490	-0.00020
4231.59600	-0.00040	4294.36960	0.00040
4232.36500	-0.00070	4294.41960	0.00020
4232.42550	-0.00010	4294.47730	-0.00010
4232.47790	-0.00030	4295.30450	-0.00080
4232.58790	-0.00040	4295.35560	-0.00050
4232.64480	-0.00070	4295.40920	0.00010
4235.33940	0.00040	4295.46880	-0.00030
4235.38910	0.00010	4295.52380	0.00000
4235.44330	0.00010	4966.85690	0.00150
4235.50320	0.00000	4966.91600	0.00070
4235.55680	-0.00020	4966.97050	-0.00030
4235.60790	0.00050	4967.84680	0.00020
4236.43430	-0.00060	4967.90590	-0.00030
4236.49280	-0.00050	4967.95880	0.00110
4236.54420	0.00040	6158.98190	-0.00020
4236.59700	-0.00020	6175.96790	0.00030
4236.65880	0.00150	6176.02570	-0.00060
4238.41770	0.00060	6183.99100	0.00000
4238.46770	-0.00030	6184.04470	-0.00080

Post-1960 Residuals

Observed Time (HJD-2430000)	Residual (Days)	Observed Time (HJD-2430000)	Residual (Days)
8636.66920	0.00020	9422.77700	0.00050
8636.72700	0.00080	9423.65170	0.00190
8636.78500	0.00000	9425.57390	0.00050
8636.83760	0.00140	9425.63380	0.00080
8639.64200	0.00070	9425.68890	0.00010
8639.69660	-0.00090	9425.73970	0.00090
8639.74800	0.00060	9426.56400	-0.00050
9387.65420	0.00100	9426.62570	0.00180
9388.58350	-0.00130	9426.72840	0.00080
9388.64200	-0.00160	9428.54930	0.00170
9388.80700	-0.00030	9428.60080	0.00080
9389.57660	0.00000	9428.65180	0.00050
9389.63110	-0.00080	9428.71200	0.00170
9389.68100	-0.00090	9429.53760	0.00080
9389.73720	-0.00160	9429.58750	0.00050
9389.79770	-0.00010	9429.64300	0.00110
9389.84790	-0.00130	9429.70300	0.00140
9391.60470	-0.00130	9431.56550	0.00030
9391.66000	-0.00200	9431.62670	0.00150
9391.72090	-0.00060	9431.67910	0.00040
9391.77200	-0.00140	9431.73070	0.00130
9391.82430	-0.00090	9756.67880	-0.00090
9392.59520	0.00060	9756.74090	0.00130
9392.65370	-0.00020	9756.79220	-0.00150
9392.70790	-0.00070	9756.84350	-0.00060
9392.75980	-0.00060	9758.76780	-0.00020
9392.81570	-0.00040	9758.82320	-0.00210
9393.64450	-0.00070	9759.75710	-0.00030
9393.69680	-0.00070	9759.81690	-0.00010
9393.74870	-0.00020	9761.79620	-0.00030
9393.80830	0.00040	9762.78310	-0.00030
9394.57630	-0.00100	9762.83520	0.00010
9395.56750	-0.00120	9763.72030	-0.00010
9395.62160	-0.00020	9763.77050	0.00000
9395.67160	-0.00100	9763.82540	-0.00040
9397.59600	-0.00050	9764.75820	-0.00060
9397.65400	-0.00060	9764.81600	-0.00170
9397.71260	0.00000	9766.74120	0.00020
9397.81660	-0.00040	9766.79870	-0.00010
9398.58640	0.00010	9766.84970	0.00060
9398.64720	0.00100	9768.77350	0.00020
9398.70060	0.00010	9768.82640	-0.00040
9398.75020	-0.00060	10142.64380	-0.00110
9398.80820	-0.00030	10142.75060	-0.00080
9400.73100	-0.00080	10143.58120	0.00120
9400.79050	-0.00020	10143.63170	-0.00020
9401.66440	0.00040	10143.68400	0.00020
9401.72400	0.00040	10143.74480	0.00160
9419.69910	0.00070	10143.79840	-0.00090
9419.74950	0.00080	10144.61900	0.00010
9420.57270	0.00050	10144.67400	-0.00070
9420.63420	0.00200	10144.73460	0.00030
9421.62380	0.00150	10144.78560	-0.00080
9421.72720	0.00090	10145.55520	-0.00090
9422.61070	0.00050	10145.60780	0.00040
9422.66130	0.00090	10145.66500	-0.00150

Observed Time (HJD-2430000)	Residual (Days)	Observed Time (HJD-2430000)	Residual (Days)
10145.72280	-0.00060	11945.64280	-0.00010
10145.77260	-0.00070	11945.69390	0.00080
10147.58980	-0.00010	11945.74950	-0.00080
10147.64720	-0.00010	11945.80950	0.00040
10147.69680	-0.00070	12389.53740	0.00100
10148.58160	0.00020	12389.58770	0.00130
10148.63440	-0.00040	12389.64100	-0.00120
10148.68580	0.00040	12392.55550	-0.00190
10148.74230	-0.00150	12392.61540	0.00060
10879.55000	0.00180	13047.07710	0.00050
10879.60870	0.00070	13047.12740	-0.00060
10879.66320	0.00090	13063.07180	0.00090
10879.71320	0.00060	13063.12330	-0.00040
10879.77270	0.00230	13110.99540	0.00160
11933.66140	-0.00060	13141.99740	0.00020
11933.71350	0.00070	13142.98350	-0.00060
11933.76590	0.00000	13280.18050	0.00160
11933.82520	-0.00060	13280.23590	0.00090
11934.53570	0.00040	13331.07570	0.00090
11934.65050	0.00040	13331.13320	0.00050
11934.70090	0.00070	13331.18370	0.00060
11934.81660	0.00040	13331.23700	-0.00010
11934.86690	-0.00050	13336.07390	-0.00150
11935.52470	-0.00200	13336.13590	0.00130
11935.58440	-0.00130	13336.18580	-0.00010
11935.63740	0.00030	13336.23790	-0.00040
11935.68900	-0.00040	13345.03670	-0.00060
11935.80200	-0.00260	13345.08790	0.00030
11936.62390	-0.00030	13379.05470	-0.00130
11936.68150	0.00090	13379.11720	0.00120
11936.73910	-0.00090	13379.16920	-0.00090
11936.79190	0.00030	13379.22080	0.00040
11936.84410	0.00050	13379.27800	-0.00020
11936.90200	-0.00120	13393.12670	0.00010
11937.50950	0.00010	13394.06150	0.00030
11937.56120	0.00000	13394.11710	-0.00070
11937.61330	0.00020	13394.17620	-0.00080
11937.67190	-0.00060	13394.22800	-0.00050
11937.72890	0.00030	13410.99300	-0.00080
11937.77900	0.00040	13411.04460	-0.00010
11937.83320	-0.00150	13411.10330	0.00000
11937.89430	0.00020	13411.16160	0.00080
11940.52690	-0.00040	13411.21120	0.00020
11940.69250	0.00150	13411.26370	-0.00190
11940.74830	-0.00150	13411.98080	0.00010
11943.55120	0.00010	13425.01360	0.00230
11943.60390	-0.00090	13425.06420	-0.00110
11943.66540	0.00070	13425.11620	0.00050
11943.76970	0.00060	13442.04750	-0.00030
11944.65450	-0.00040	13618.26590	-0.00080
11944.70670	0.00110	13633.21150	-0.00020
11944.75950	0.00060	13644.15100	0.00030
11944.81810	-0.00060	13644.20360	-0.00090
11944.87350	0.00030	13644.26650	0.00200
11945.52930	0.00100	13644.31740	-0.00090
11945.58790	-0.00020	13709.06890	0.00070